

A new species of Fissurellidae (Gastropoda: Vetigastropoda) from the deep-sea off the eastern Pacific coast of Mexico

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ABSTRACT

The present article describes *Fissurella hendrickxi*, a new deep-sea gastropod species found off the Pacific coast of Mexico (Baja Peninsula; Gulf of California), at 650–837 m depth, collected by the TALUD XV and TALUD X projects. *Fissurella hendrickxi* was classified according to shell sculpture, radula, epipodium, and ctenidial structure. It is remarkable for its very thin shell, which covers the entire animal.

Additional Keywords: Deep sea, *Fissurella*, continental slope

INTRODUCTION

Recent surveys of deep-water environments off the Pacific coast of Mexico have discovered new molluscan species. Such studies seldom yield mollusk samples, because available sampling techniques are not always adequate or only few sediment samples are collected, thus preventing a thorough inventory of the continental shelf, slope, and the abyssal plain (Zamorano et al., 2013; McLean and Geiger, 1998).

The Fissurellidae comprises four subfamilies: Fissurellinae, Diodorinae, Emarginulinae, and Hemitominae, with Fissurellinae containing six genera, which are diagnosed by shell and radular characters (Thiele, 1891; 1912; 1929; McLean, 1984a; 1984b; Hickman, 1998). Members of the Fissurellidae are most frequently found in the intertidal or shallow waters worldwide and are not as prevalent in deep waters. Some genera and species of Fissurellidae have been recorded in deep waters of the eastern Pacific off South America (McLean and Geiger, 1998; Araya and Geiger, 2013). McLean (1971) documented deep-water Fissurellidae species [*Emarginula velascoensis* Shasky, 1961, *Zeidora flabellum* (Dall, 1896), and *Cranopsis expansa* (Dall, 1896)] in the Gulf of California and/or along the Baja Peninsula with bathymetric ranges around 200 m.

MATERIALS AND METHODS

The new species was collected during the TALUD X and TALUD XV projects (2007 and 2012), on board the

Universidad Nacional Autónoma de México (UNAM) research vessel EL PUMA along the western coast of Baja California Sur and in the Gulf of California. Station depths were estimated with a SIMRAD echo-sounder. Temperature and dissolved oxygen measurements were collected 20 m above the seafloor with a Seabird CTD multisensor probe. Oxygen measurements were checked by titration (Strickland and Parsons, 1972). Morphological descriptions include the following dimensions: length (L), width (W), and height (H). Fixed specimens were photographed for their external anatomy. Specimen preparation and SEM imaging were performed following Geiger et al. (2007). Cross sections of shells were imaged from broken pieces. Measurements were taken from a middle section and a section containing the parts of the foramen.

Specimens are deposited at the Santa Barbara Museum of Natural History (SBMNH), and the Regional Collection of Marine Invertebrates at the Mazatlán Marine Station, UNAM, in Mazatlán, Mexico (EMU-ICML).

Abbreviations used in the figures are: **an**: anus; **ct**: cephalic tentacle; **et**: epipodial tentacle; **ey**: eye; **fo**: foramen; **ft**: foot; **gi**: gill; **gs**: gill suspensory stalk; **mb**: mantle border; **mt**: mantle tentacles; **mo**: mouth; **sn**: snout.

SYSTEMATICS

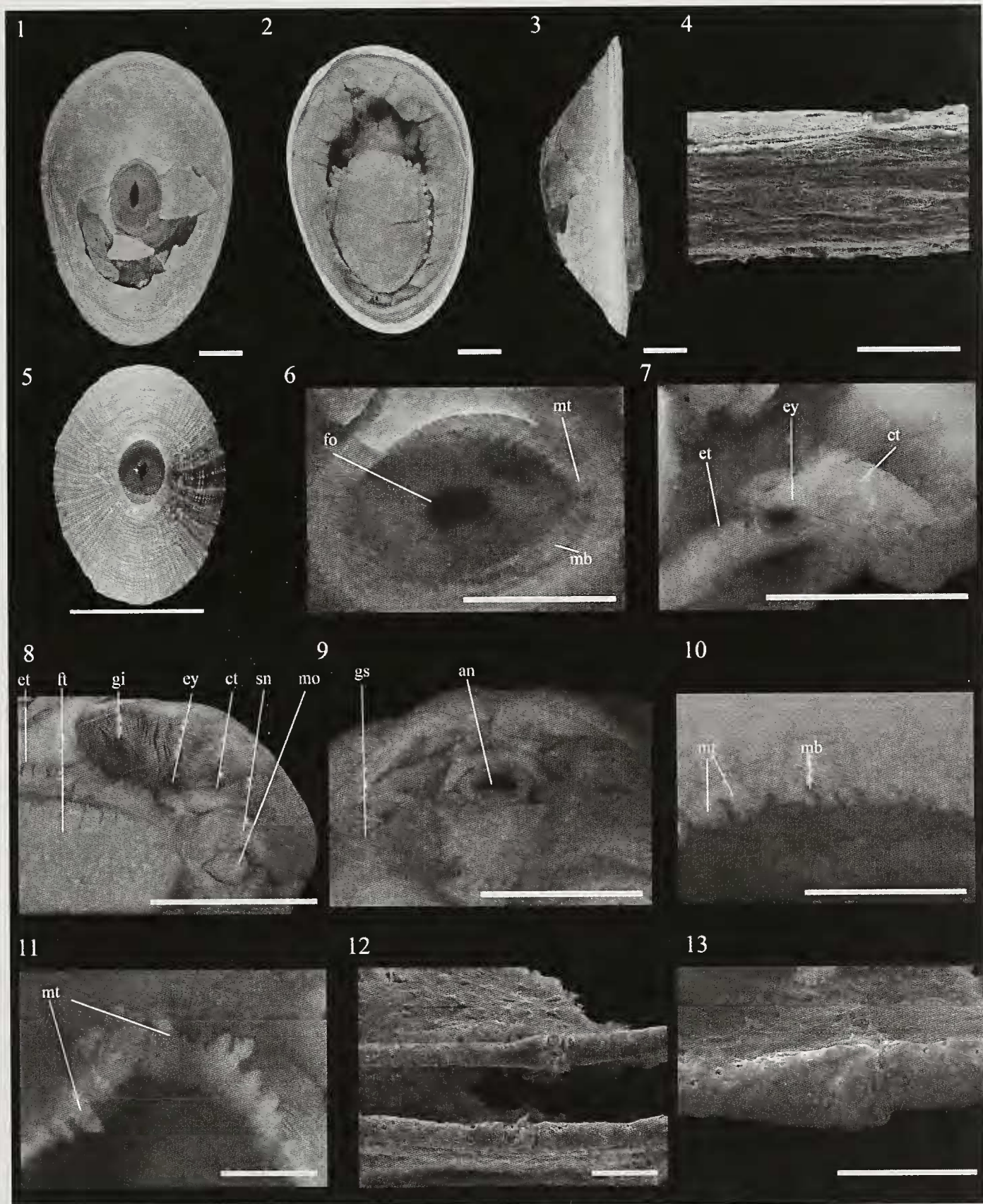
Class Gastropoda Cuvier, 1797
Suborder Vetigastropoda Salvini-Plawen, 1980
Family Fissurellidae Fleming, 1822
Subfamily Fissurellinae Fleming, 1822

Genus *Fissurella* Bruguière, 1789

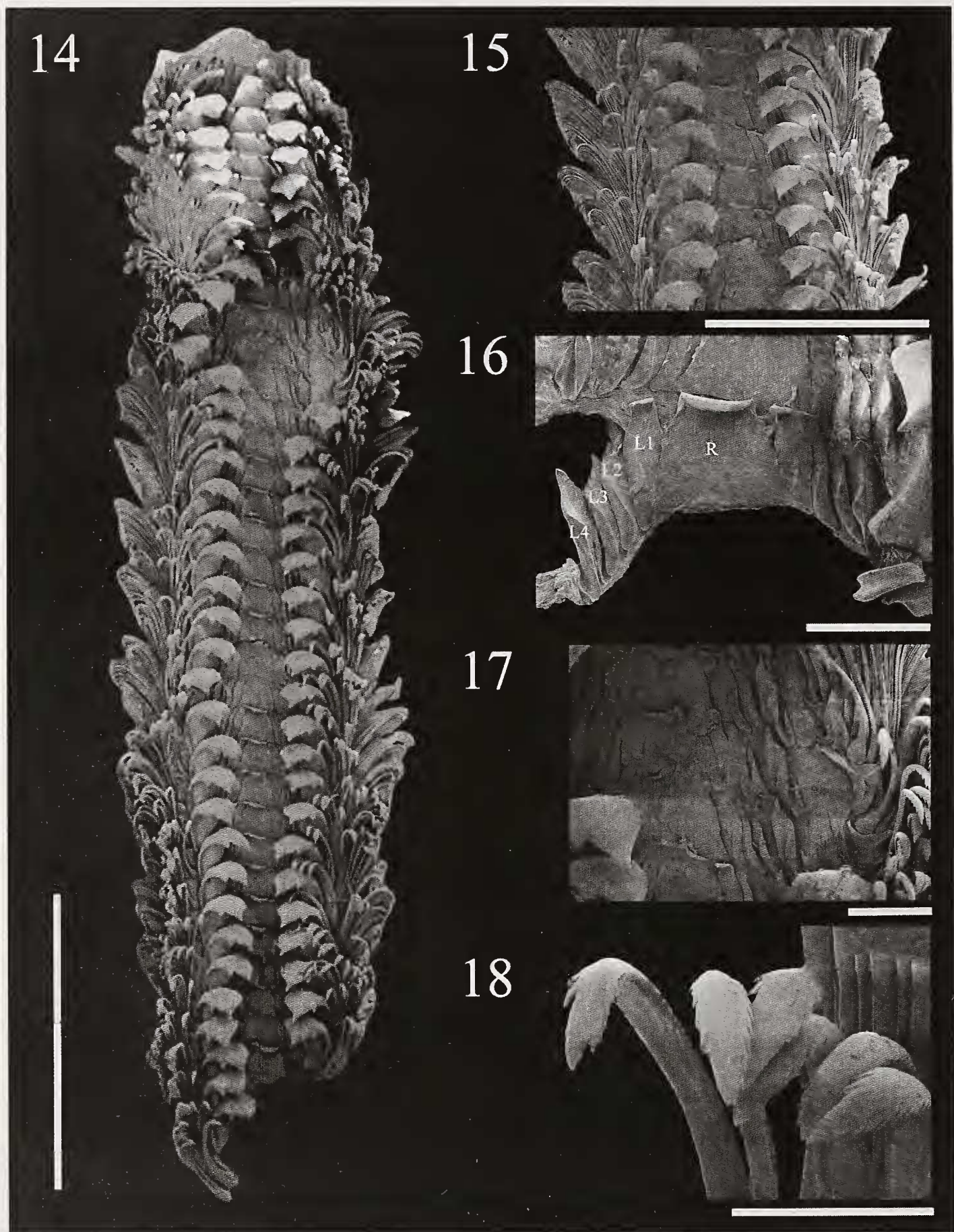
Type Species: *Fissurella nimbosa* Linnaeus, 1758 (by monotypy).

Fissurella hendrickxi new species (Figures 1–18)

Diagnosis: Shell up to 42.9 mm; foramen elliptical, central. Shell extremely thin (~0.1 mm). Specimens smooth



Figures 1–13. *Fissurella hendrickxi* new species. Holotype, SBMNH 457424. **1.** Dorsal view. Scale bar = 10 mm. **2.** Ventral view. Scale bar = 10 mm. **3.** Holotype, lateral view. Scale bar = 10 mm. **4.** Shell thickness (SEM). Scale bar = 100 μ m. **5.** *Fissurella hendrickxi* new species (small specimen), EMU-ICML 11338. Scale bar = 10 mm. **6.** Foramen with tentacles and remnants of shell. Scale bar = 5 mm. **7.** Detail of eye, cephalic tentacle and epipodial tentacle. Scale bar = 5 mm. **8.** Right gill, epipodium, foot, eye, cephalic tentacle, snout, and mouth. Scale bar = 10 mm. **9.** Rectal opening with granular fecal matter. Scale bar = 5 mm. **10.** Mantle border and mantle tentacles above foot. Scale bar = 2 mm. **11.** Enlargement of posterior tentacle surrounding foramen. Scale bar = 1 mm. **12.** Bursicle. Scale bar = 100 μ m. **13.** Enlargement of bursicle. Scale bar = 100 μ m.



Figures 14–18. *Fissurella hendrickxi* new species. Radula under SEM. Paratype SBMNH 235544. **14.** Entire radula. Scale bar = 2 mm. **15.** Whole width of radula. Scale bar = 1 mm. **16.** Central field with rachidian tooth and lateral teeth. Scale bar = 200 μm . **17.** Lateromarginal plate. Scale bar = 200 μm . **18.** Marginal teeth. Scale bar = 100 μm .

due to erosion at top, concentric lines at shell bases, small specimens with primary and secondary cords. External shell color dull whitish.

Description: Shell height moderate (about 30% of length), outline elliptical, a bit narrow at posterior end (Figures 1–3). Width about 60–70% of length (Figures 6). Foramen central and conical, 20–22% of length (Figures 6). Shell extremely thin (Figure 4); callus of foramen 0.16–0.17 mm remainder of shell 0.1 mm. Profiles straight. Radial sculpture of alternating primary, secondary cords regularly spaced. Concentric sculpture generally weak, strongest close to edges. Larger specimens with concentric lines at shell bases, radial sculpture absent. Small specimens with radial and concentric sculpture (Figure 5). Foramen area eroded. Color external dull whitish; inner surface whitish, glossy.

HEAD AND FOOT (Figures 7–9):

Eyestalk narrower than cephalic tentacles, approximately $\frac{1}{4}$ of cephalic tentacle length, located just posterior to origin of cephalic tentacles. Eye almost half as wide as diameter of eyestalk. Snout cylindrical, tapering, surrounding central mouth. Epipodium with approximately 34–36 tentacles arranged in single horizontal row terminating at neck; tentacles varying in size by factor two, larger ones approximately as long as eyestalk. Cephalic

tentacle located on each side of snout, each tentacle tapering gradually (wider at base than at tip), tip pointed, with different folds around tentacle, slightly shorter than snout. Foot thick, 60% of the shell length.

MANTLE ORGANS (Figures 10–13):

Mantle margin close to shell, smooth exterior fold, interior fold wider than middle fold; mantle tentacles in middle fold; mantle margin of foramen similar. Gill hypertrophied, filaments symmetrical, with rounded tip; bursicles present. Anus elliptical, located at posterior end of pallial cavity.

RADULA (Figures 14–18):

Rachidian tooth trapezoidal, broad. Five lateral teeth, with narrow inner teeth. Lateromarginal plate triangular, without projections, sinuous distal edge. Marginal teeth with spoon-shaped pointed tip, with fine denticles on each side of the apical margin.

Type Material: **Holotype** SBMNH 457424: $34.7 \times 10.6 \times 22.7$ mm (L×W×H), 4 **paratypes**, all from type locality: SBMNH 235544: $42.9 \times 11.5 \times 22.3$ mm, $32.9 \times 10.93 \times 22.0$ mm (L×W×H), EMU-ICML 10965: $35.6 \times 22.3 \times 11.9$ mm (L×W×H), EMU-ICML 10966: $30.2 \times 20.7 \times 8.2$ mm (L×W×H).

Type Locality: Baja California Sur Peninsula, Mexican Pacific, Mexico, TALUD XV, St. 5D, $23^{\circ}16'58''$ N; $110^{\circ}20'42''$ W, 650–665 m (Figure 19).

Other Material Examined: Seven specimens, EMU-ICML 11338, TALUD XV st. 5D, Baja California Sur Peninsula, Pacific Ocean, Mexico, $23^{\circ}16'58''$ N, $110^{\circ}20'42''$ W; one specimen, EMU-ICML 11339, TALUD XV, St. 20, Baja California Sur Peninsula, Pacific Ocean, Mexico, $26^{\circ}30'42''$ N, $113^{\circ}56'0''$ W; one specimen, EMU-ICML 11340, TALUD X, St. 5, Gulf of California, Mexico, $28^{\circ}14'50''$ N, $112^{\circ}24'53''$ W.

Environmental Conditions: Dissolved oxygen, 0.08–0.15 mlO₂/l; temperature, 6.2–8.4°C; salinity, 34.55–34.68‰.

Etymology: Named after Michel E. Hendrickx (Instituto de Ciencias del Mar y Limnología, Mazatlán, Sinaloa, México), who for long time has long studied the benthic fauna of the eastern Pacific Coast of Mexico, in particular from off the Baja Peninsula and the Gulf of California.

Comparisons: The radula with very large lateral tooth 5, whose tip aligns with the lateral teeth of the subsequent row (see McLean and Kilburn, 1986) places our species in Fissurellinae, and not in Emarginulinae, which includes the genus *Stromboli*. The absence of an internal thickening around the foramen differentiates the species from the otherwise similar *Diodora*. Among the genera in Fissurellinae, genera other than *Fissurella* either exhibit strong shell reduction (*Amblychilepas*, *Leurolepas*,

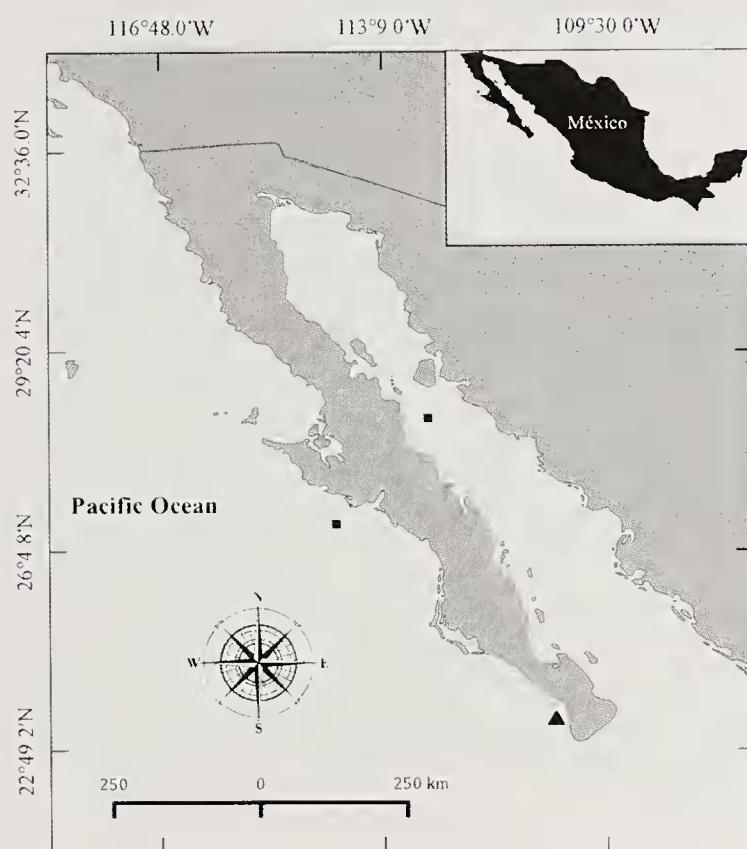


Figure 19. Distribution of sampling stations where specimen of *Fissurella hendrickxi* new species were collected during the TALUD XV and X surveys off the western coast of the Baja California Peninsula and Gulf of California (▲ = type locality).

Macroschisma), or show strong propodial elaborations (*Dendrofissurella*). All approximately 46 recent species of *Fissurella* have much thicker shells than the new species.

The two species overall most similar to *Fissurella hendrickxi* are in genera other than *Fissurella*; these are *Diodora codoceae* (McLean and Andrade, 1982) and *Stroumboli beebei* (Hertlein and Strong, 1951). They share a large and thinner than usual shell with a large foramen that is conical in shape, and the interior shell color is white. *Diodora codoceae* and *S. beebei* differ from the *F. hendrickxi* in their fleshy mantle that fully envelops the edge of the shell and radial ribs that are uniformly fine, with no distinction between primary and secondary ribs (McLean and Andrade, 1982). They both also have a much sturdier shell than *F. hendrickxi* and the sculpture is stronger in *S. beebei* and *D. codoceae*. The shells of both species are noticeably thicker: *D. codoceae* 1.05 mm at length of 36.5 mm (SBMNH 172216); *S. beebei* 1.03 mm at length of 31.75 mm (SBMNH 118681).

Remarks: *Fissurella hendrickxi* was collected just below the oxygen minimum zone < 0.5 ml O_2/l (OMZ); fully oxygenated seawater can hold > 7 ml O_2/l (Levin 2002). While the oxygen measurements were taken some 20 m above the sea floor (due to equipment limitations), it gives a reasonable indication of the conditions prevailing in the species habitat.

Shell sculpture changes with growth. Small specimens (smallest specimen 18 mm) have radial and concentric elements whereas larger (> 35 mm) specimens only have concentric sculpture at the shell margin. This difference may be accounted for by erosion and/or physical wear of the shell. However, low carbonate assimilation levels or adaptive changes among large organisms may also play a role.

The epipodium, a complex of sensory or tactile structures located on the sides of the foot under the shell margin of the vetigastropods (Macdonald and Maino, 1964; Cox, 1962; Crisp, 1981), has proven useful in taxonomic and systematic classification (Hickman and McLean, 1990; Geiger, 1999; Collado, 2008; Collado et al., 2012). The epipodium of *F. hendrickxi* is particularly well-developed compared to other species in the genus. This enlargement may be an adaption to extreme environmental conditions such as low oxygen concentrations or depth. Alternatively, it may improve mobility and tactile sensitivity in soft sea-beds.

DISCUSSION

The diversity of deep-sea mollusks in the Pacific coast of Mexico is not well documented. Most species of Fissurellidae from that area occur in relatively shallow water (0–50 m) on hard substrates. Few deep-water and soft seabed species are known [e.g., *Cornisepta guzmami* Araya and Geiger, 2013; *C. pacifica* (Cowan, 1969); *C. leviniae* McLean and Geiger, 1998; *C. uirapa* Simone and Cunha, 2014].

Fissurella hendrickxi was found in an environment under hypoxic conditions, which characterizes this region of the eastern Pacific, where the oxygen minimum zone exhibits significant latitudinal variations in depth, thickness, and intensity (Helly and Levin, 2004). Whether the enlarged epipodium in the species is an adaptation to deep-water conditions remains unknown. The comparatively large gill is remarkable, and additional, indirect evidence that the species may be adapted to that particular environment.

Specimens described here were collected from the continental slope region at depths > 200 m. Larger organisms feature decreased shell thickness, a potential adaption to low energy environments. McLean (1984c) noted that the limpet shape may prove advantageous, as it provides protection through clamping against the substratum. Species living on soft bottoms can no longer clamp down, and the protective function of a thick shell does no longer apply.

Fissurellidae is an interesting lineage with respect to shell reduction, including complete loss of the shell in *Buchanania*. Reduction of shell thus far has mostly been achieved by reduction in size while maintaining shell thickness. Examples of moderate reduction include *Megathura* and *Scutus*, while extreme reduction is encountered in *Macroschisma*. *Fissurella hendrickxi*, on the other hand, has reduced shell thickness while retaining a large size. It is the only species in Fissurellinae with fully grown shell so thin that it does not offer any protective function anymore (The specimens recovered had gonads indicating maturity.) Similarly thin shells are only known from deep-water *Emarginulinae*, but those are overall much smaller (~ 2 –10 mm: McLean and Geiger, 1998).

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